US Army Corps
of Engineers
Detroit District

Great Lakes Update

Volume 189: 2013 January through June Summary

The U.S. Army Corps of Engineers (USACE) tracks the water levels of each of the Great Lakes. This report highlights hydrologic conditions of the Great Lakes basin between January and June 2013, evaluates what has caused water level extremes on Lake Michigan-Huron since 1950, and examines the individual hydrologic components of the water cycle by decade. The three primary Great Lakes hydrologic components are precipitation which falls on the lake surface, runoff draining to the lake, and evaporation from the lake surface. Runoff is defined as precipitation which falls on the land drainage area and flows to the lake.

The period of record used for each of the lakes includes the years 1918 to 2012 and this data has been coordinated between the United States and Canada. All 2013 water levels are considered provisional and will be officially coordinated in the spring of 2014. The elevations used are referenced to the 1985 International Great Lakes Datum. The water level of each lake is averaged from a network of individual gages around each lake. Also of note is that Lake Michigan and Lake Huron are hydraulically treated as one lake due to their connection at the Straits of Mackinac.

2013 Summary: January - June

At the beginning of 2013 all of the Great Lakes water levels were well below their long-term averages. Lake Michigan-Huron's January 2013 monthly mean water level set an all-time record low of 576.02 ft. Lake Superior's January level was 13 inches below the long-term average (LTA) and Michigan-Huron's level was 29 inches below LTA. Lake St. Clair was 13 inches below LTA in January 2013 while lakes Erie and Ontario were each 7 inches below their LTA.

Seasonal changes in the weather patterns typically cause an annual pattern of rising and falling water levels. In general, each of the Great Lakes exhibits a seasonal rise in the spring primarily caused by an increase in precipitation, the melting of accumulated snow, and an increase in runoff. The seasonal decline of the water level in the fall and winter is primarily caused by an increase in evaporation and the accumulation of snowpack on the land area.

Since January 2013, all of the Great Lakes water levels have increased more than they typically do from January to June. Currently each of the Great Lakes is closer to its LTA, and Lake Ontario has actually risen above its LTA.

Comparison of 2013 with Historical Record

The water level rise from January to June in 2013 is compared with each January to June rise in the historical record, which dates back to 1918. The January to June time period does not represent each lake's total seasonal rise, because the timing of seasonal maximums and minimums varies from lake to lake. This analysis is simply highlighting what has happened so far in 2013. Table 1 below shows the 2013 water level rise in units of inches, the LTA rise, the last 10 years, and the 2013 ranking among the 96 years of the historical record. Figure 1 shows the historical record of Great Lakes water levels.

Figure 1: Great Lakes Water Levels (1918-2012)

[Elevations are referenced to IGLD85]

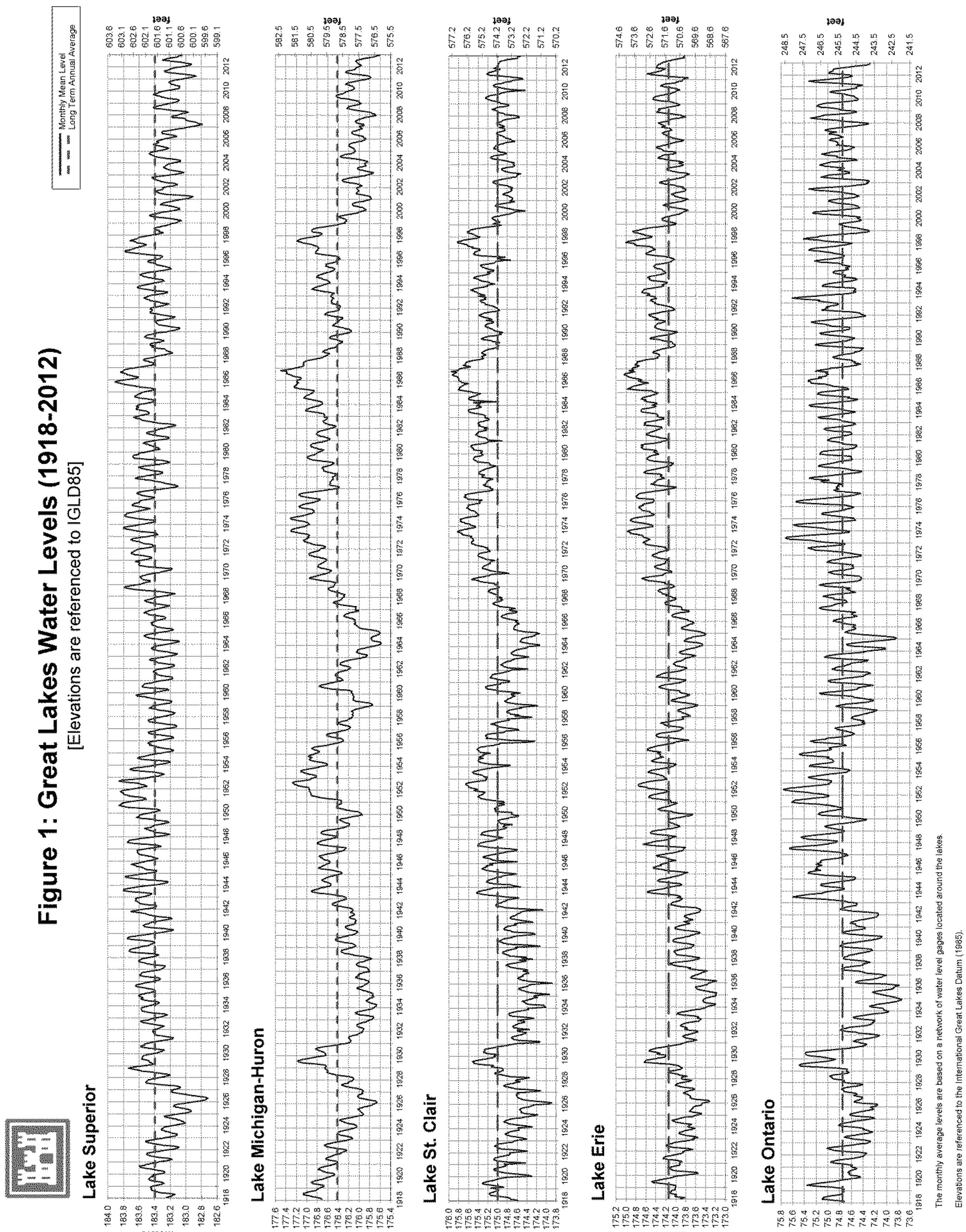


Table 1: Great Lakes Water Level Changes from January to June (inches)

Lake	Water Level Change (June monthly mean minus January monthly mean), inches											2013 Rank Among Historical Record (out of 96)
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	LTA (1918-2012)	
Superior	8	3	2	1	8	6	-3	6	7	11	5	5th
Michigan-Huron	17	5	10	3	18	16	2	16	3	19	9	5th
St. Clair	17	2	10	1	15	12	13	29	-2	18	13	24th
Erie	17	4	11	-1	16	16	13	30	-7	16	13	32nd
Ontario	12	11	10	0	25	16	13	33	4	28	19	13th

There were noticeable dry periods in the years 2005 and 2007 across all of the Great Lakes for the January through June time period. In these two years, all of the lakes were below their typical water level rises. There were significant wet periods in the years 2008 and 2011, where the January to June changes for all of the Great Lakes were greater than their typical rises.

Although the first half of 2010 was a very dry period for lakes Superior and Michigan-Huron, the water level changes for St. Clair and Erie matched their averages. Lake Ontario rose less than the typical amount in 2010. The 2010 example shows how the hydrologic conditions can be different from one Great Lake basin to another.

There are also significant changes which occur from year to year. For example, 2007 and 2008 exhibited very different behavior for each of the Great Lakes. Likewise, 2010 to 2012 were also very different in their January to June water level changes from one year to the next.

The 2012 January to June water levels rose more than the typical amount for Lake Superior. However, all of the other Great Lakes exhibited very low water level changes. Lakes St. Clair and Erie actually dropped during the January to June time period, exhibiting differences below average of 15 and 20 inches, respectively. Lake Michigan-Huron's very low spring rise in 2012 was one of the factors which led to the all-time record low water level in January 2013.

The last column of Table 1 shows the comparison between 2013 and the historical record. The 2013 January to June rise was the 5th highest for both Lakes Superior and Michigan-Huron, 24th highest for Lake St. Clair, 32nd highest for Lake Erie, and 13th highest for Lake Ontario.

2013 Net Basin Supplies

Water level changes are primarily determined by the balance of the following factors: precipitation falling on the lake surface, runoff draining to the lake, evaporation from the lake surface, diversions into or out of the lake, and connecting channel inflows and outflows. The Net Basin Supply (NBS) is an important quantity for understanding the amount of water which arrives to the lake. USACE uses the residual method to compute NBS which is equal to the water level change, minus the inflow from an upstream lake, plus the outflow, and plus any diversions out of (+) or into (-) the lake. Altogether, NBS represents the combined effects of precipitation, runoff, and evaporation. NBS is far and away the main driver of water levels.

Each lake's NBS was totaled for the months of January through June. The NBS totals for January through June 2013 were greater than the historical averages for all of the Great Lakes. The NBS totals for each lake are shown in Table 2 in units of inches of water over the lake surface. The historical record of NBS uses a period of record of 1900 to 2008 for all of the Great Lakes except Lake Ontario. The Lake Ontario NBS period of record is 1900 to 2005.

Table 2: Great Lakes Net Basin Supply Totals from January to June (inches over the lake)

Lake	2013	LTA (1900 – 2008)**
Superior	23	19
Michigan-Huron	34	27
St. Clair*	238	107
Erie	38	32
Ontario	56	51

*The smaller surface area of Lake St. Clair causes the NBS totals to be distorted when looking at the depth of water on the lake surface.
**The Lake Ontario average NBS is based on period of 1900 – 2005.

The Great Lakes have experienced some extremely wet NBS amounts in specific months of 2013. In particular, Lake Superior's NBS was the 2nd highest ever for the month of May in 2013. Lake Michigan-Huron's NBS was the 2nd highest ever for the month of April in 2013. Lakes St. Clair and Erie experienced an extremely wet June, with their highest ever NBS amounts for the month of June in 2013. The Lake Ontario NBS was the 4th highest ever for the month of June in 2013.

Hydrologic Components by Decade

To further understand the fluctuations in Great Lakes water levels, this section examines the three primary hydrologic components of the water balance over the past six decades; namely precipitation, runoff, and evaporation. The annual totals of each component were computed and then the totals for each year were averaged by decade: 1950 to 1959, 1960 to 1969, etc. The period of record of coordinated precipitation data spans 1900 to 2010. Runoff and evaporation data used here comes from the National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory (GLERL). Runoff data was computed by GLERL using an area-weighted approach of extrapolating gauged drainage areas. Evaporation estimates are from GLERL's Large Lake Evaporation and Thermodynamics Model which has recently been updated in 2013. This analysis begins in 1950 because that is the earliest that all three data sets are available. Prior to 1950, there is insufficient data which is required for the evaporation model. All data has been converted to an equivalent depth of water on the lake's surface.

Figures 2 through 6 show the decadal averages of annual precipitation, annual runoff, and annual evaporation for each lake over the past six decades. These figures offer a large time-scale perspective of the component estimates. Specific annual totals may vary significantly from their decade's average.

One observation from the figures below is the relative influence of each component varies from lake to lake. For lakes St. Clair and Ontario, runoff is more influential than precipitation and evaporation due to the large ratio of drainage area to lake surface area. Another observation is that the transition from the lower water levels of the 60's to the higher water levels of the 70's and 80's was driven by a general increase in precipitation and runoff for all of the lakes during that time period, with the exception of Lake Superior's estimated runoff being low in the 80's.

The figures also show that evaporation has generally increased on the Great Lakes from the 1960's to the 2000's. Lakes Superior and Michigan-Huron exhibited an especially large jump from the 1990's to the 2000's. This is a large contributing factor to these two lakes being in a consecutive 14-year period of below average water levels, the longest stretch in each of their recorded histories.

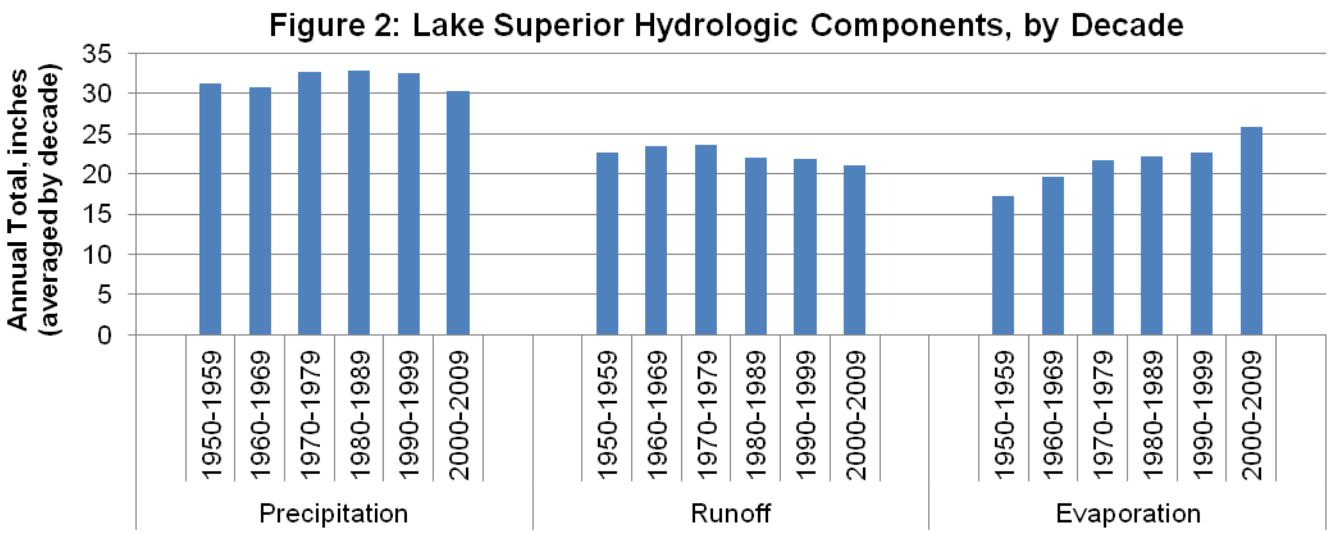


Figure 2: Lake Superior Hydrologic Components, by Decade
Annual Total, inches (averaged by decade)
35
30
25
20
15
10
5
0
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
Precipitation
Runoff
Evaporation

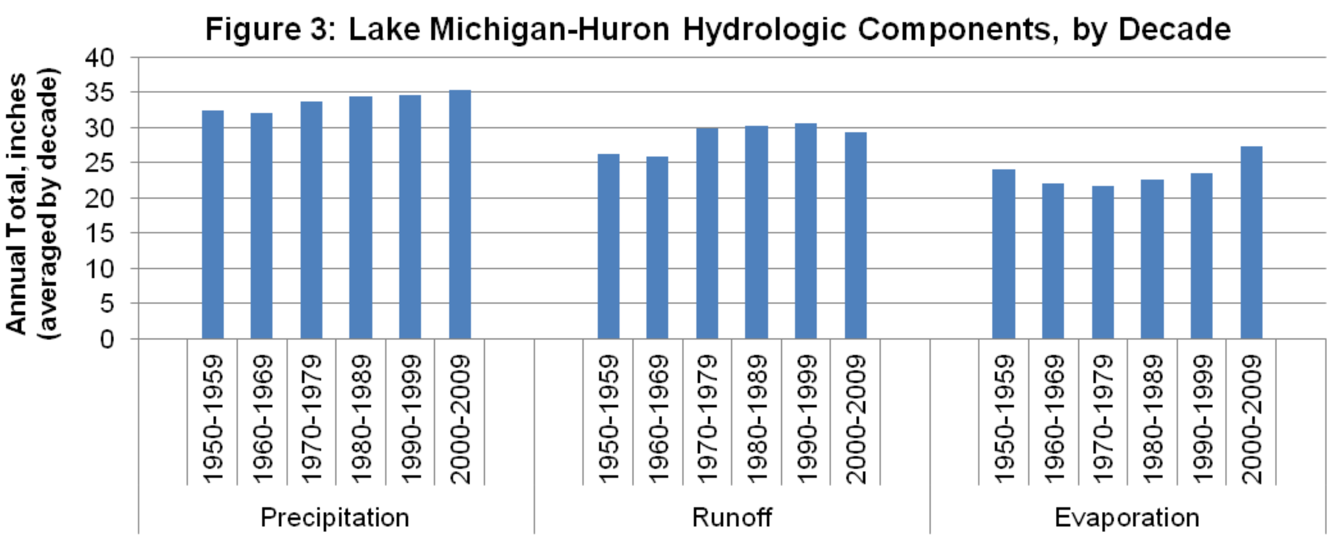


Figure 3: Lake Michigan-Huron Hydrologic Components, by Decade
Annual Total, inches (averaged by decade)
40
35
30
25
20
15
10
5
0
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
Precipitation
Runoff
Evaporation

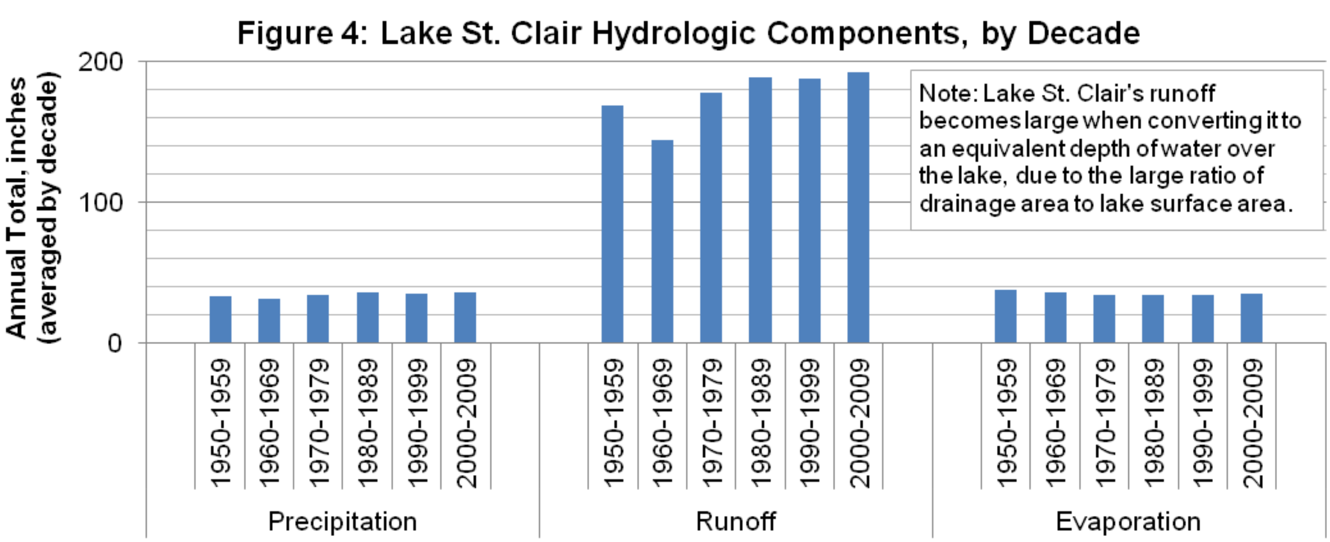
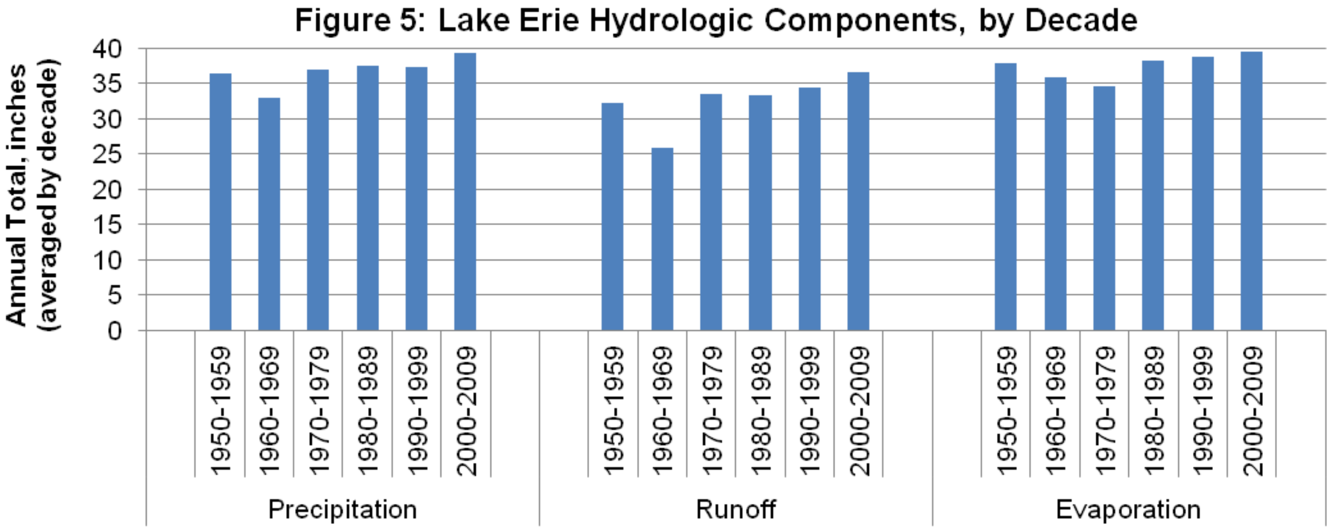
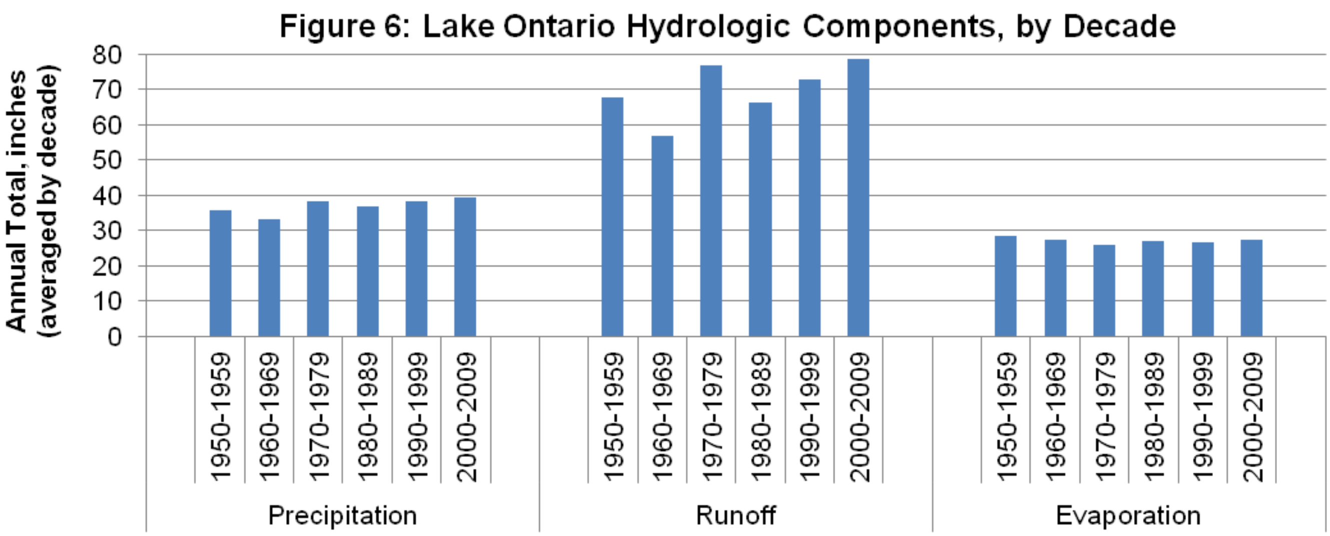


Figure 4: Lake St. Clair Hydrologic Components, by Decade
Annual Total, inches (averaged by decade)
200
100
0
Note: Lake St. Clair's runoff becomes large when converting it to an equivalent depth of water over the lake, due to the large ratio of drainage area to lake surface area.
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
Precipitation
Runoff
Evaporation





Causes of Water Level Extremes on Lake Michigan-Huron Since 1950

The water level of Lake Michigan-Huron set a new all-time record low in January 2013 at a water level of 576.02 ft, breaking the previous record low water level of 576.05 ft set in March of 1964. This section looks at periods of high and low Michigan-Huron water levels over the last 60 years and examines the primary contributing factors leading to the water level extremes.

The three periods of interest are 1955 to 1964, 1965 to 1997, and 1998 to present. As seen in Figure 1, Lake Michigan-Huron experienced record low water levels in the first time period (1955 to 1964), record high water levels in the second time period (1965 to 1997), and low water levels again in the third time period (1998 to present). Due to its very large size, extreme water levels on Lake Michigan-Huron are not caused by a single storm, but rather by consecutive seasons or years of persistent wet or dry conditions.

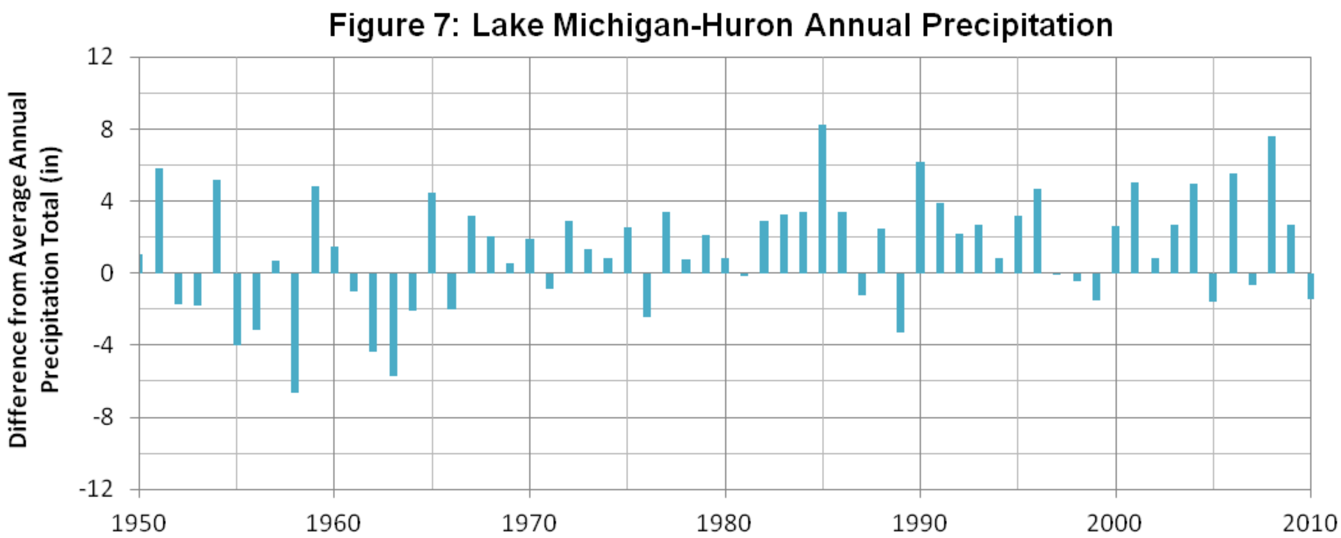


Figure 7: Lake Michigan-Huron Annual Precipitation
Difference from Average Annual Precipitation Total (in)
12
8
4
0
-4
-8
-12
1950
1960
1970
1980
1990
2000
2010

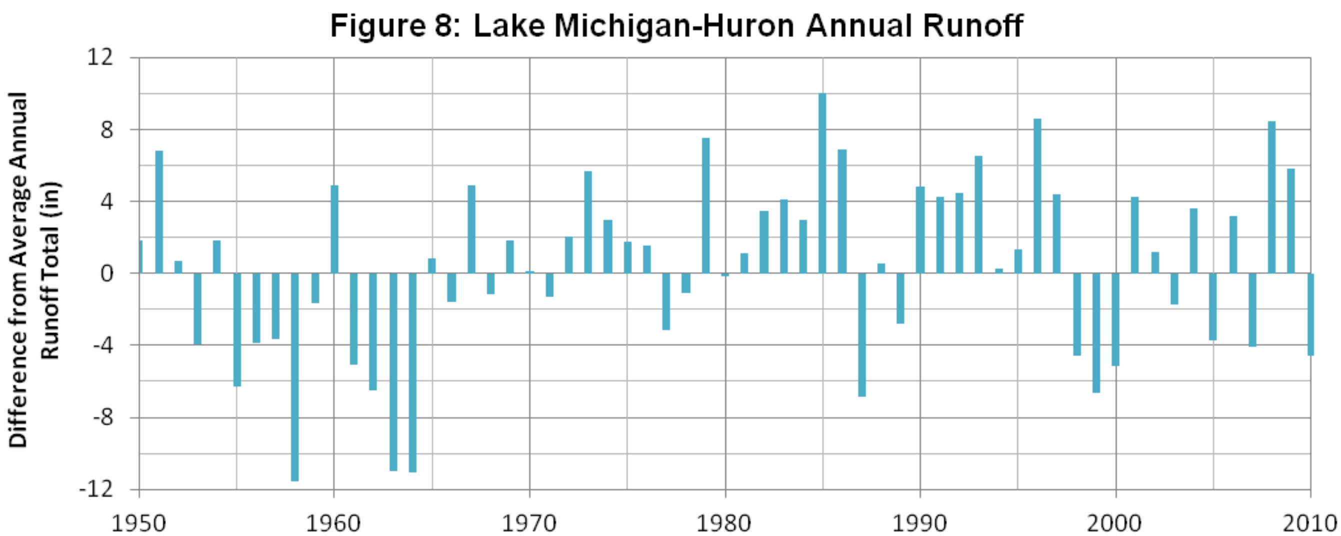


Figure 8: Lake Michigan-Huron Annual Runoff
Difference from Average Annual Runoff Total (in)
12
8
4
0
-4
-8
-12
1950
1960
1970
1980
1990
2000
2010

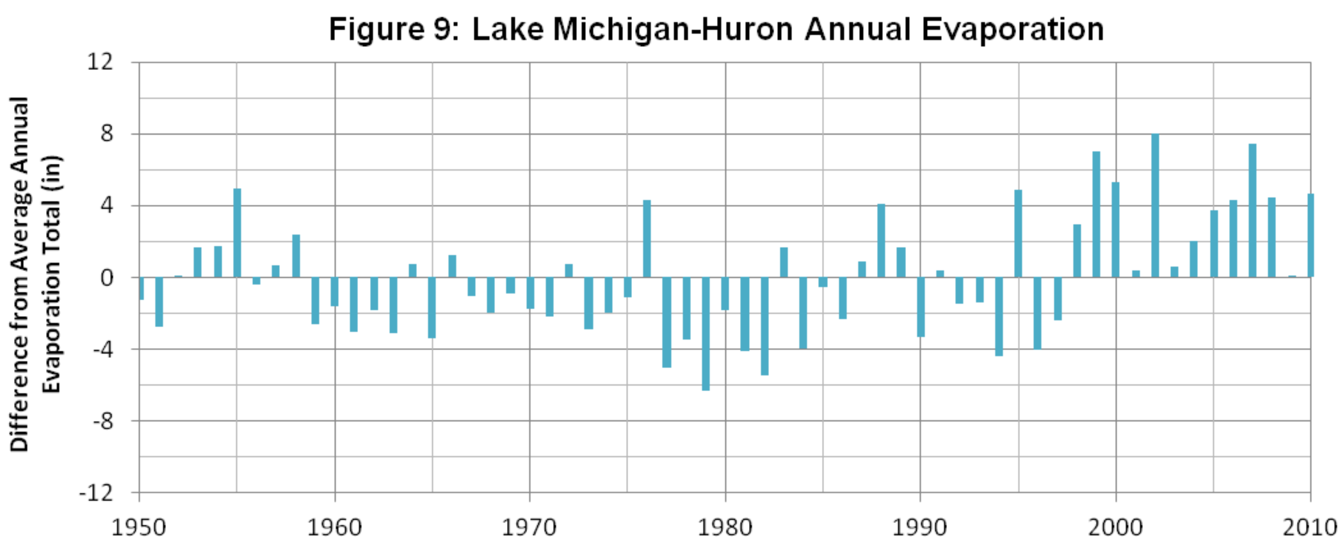


Figure 9: Lake Michigan-Huron Annual Evaporation
Difference from Average Annual Evaporation Total (in)
12
8
4
0
-4
-8
-12
1950
1960
1970
1980
1990
2000
2010

The primary hydrologic components are shown in Figures 7 – 9 to highlight the causes of extreme water levels in the above-mentioned time periods. The annual data for each component is converted to an equivalent depth of water over the lake surface. The data is shown relative to the annual average, so positive values indicate above average quantities and negative values indicate below average quantities. The sources of data are the same as mentioned in the previous section "Hydrologic Components by Decade". As noted there, the evaporation data set is only available back to 1950.

In the 1955 to 1964 time period, there are some important features which are noticeable, particularly in Figures 7 and 8. Precipitation totals and runoff totals are clearly well below average in this time period. Over the 10 consecutive year period, there are 8 years with below average precipitation and 9 years with below average runoff. Further, both of the two lowest annual precipitation totals are in this period and the three lowest annual runoff totals occur in this time period. The persistently below average amount of precipitation and runoff is the primary cause of the record low levels of 1964.

All three hydrologic components contributed to high water levels in the 1965 to 1997 time period. Precipitation was above average for 26 out of the 33 consecutive year period and runoff was above average for 25 out of 33 years. Evaporation was below average in this time period for 24 out of 33 years. In fact, the 10 lowest evaporation totals all occurred in the period from 1965 to 1997. The year 1985 recorded the highest annual precipitation and runoff. The persistently wet conditions led to high water levels throughout this period with the record high water level occurring in 1986.

An interesting transition occurred in 1998 as the annual runoff dropped and the annual evaporation rose. The three-year period of low runoff and high evaporation from 1998 to 2000 caused the Michigan-Huron level to plummet, as can be seen in Figure 1. This was the beginning of the current 14 consecutive year stretch of below average water levels for Lake Michigan-Huron, the longest in its recorded history. Evaporation is the primary cause of the ongoing low water levels, as is evident in Figure 9. Evaporation has been above average since 1998 and the four highest annual evaporation totals all occurred between 1998 and the present. One of the primary factors in determining evaporation is water temperature, and annual Michigan-Huron water temperatures have been above average since 1998.

More Information

The Detroit District recently migrated to a new website. The website address for the Detroit District home page remained the same, but links to specific pages have changed. Below is a list of links which may be of interest:

Home page: *http://www.lre.usace.army.mil*

Great Lakes Information: *http://www.lre.usace.army.mil/Missions/GreatLakesInformation.aspx*

Water Levels & Forecasts: *http://www.lre.usace.army.mil/Missions/GreatLakesInformation/GreatLakesWaterLevels.aspx*

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